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# The Impact of Globalization on the U.S. Defense Industrial Base

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The Center for Public Policy and Private Enterprise at the University of Maryland's School of Public Policy provides the strategic linkage between the public and private sector to develop and improve solutions to increasingly complex problems associated with the delivery of public services—a responsibility increasingly shared by both sectors. Operating at the nexus of public and private interests, the Center researches, develops, and promotes best practices; develops policy recommendations; and strives to influence senior decision-makers toward improved government and industry results.

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# Executive Summary

The nation's military strategy, in large part, continues to depend on superior technology, highly qualified operational forces, and the ability to sustain those forces, in order to achieve its objectives. However, in spite of fact that the U.S. defense industrial base—and the global defense industrial base—have changed significantly since the end of the Cold War, current U.S. defense policy amounts to little more than the consolidation of numerous incremental changes that are often contradictory in their aims. The impacts of globalization on defense must be better understood so that policy-makers can better balance the requirements of defense industrial and trade policy with political, economic, and security considerations.

Globalization is the long-term, largely irreversible phenomenon involving the political, cultural, and economic merging of geographically dispersed groups of people across geopolitical lines (Defense Science Board [DSB], 1999). With the advent of modern transportation and communication technologies, the implications of globalization have grown exponentially. In the past, the U.S. industrial base would ramp-up production to meet the needs of the U.S. military, and then fade into the background when the conflict concluded. Throughout the Cold War, however, defense emerged as a permanent segment of America's industrial base, providing dedicated development and production of systems, equipment, and supplies. Rather than mobilize the U.S. civilian economy for conflict, the military sought to develop sufficient permanent capacity within the defense industry to successfully engage in conflicts as they arose (Gansler, 1980).

The end of military tensions between the former Soviet Union and the United States ushered in a major restructuring of the defense industry. Four major developments precipitated a new environment in which the post–Cold War defense industrial base now operates: (1) major cuts to the defense budget; (2) the commercial sector entrance into high-tech research and development (R&D); (3) the offshoring and outsourcing of technology R&D and production; and (4) the DoD's shift towards net-centric warfare, a strategy informed by increasingly sophisticated and complex communications and information technology becoming available.

In 1993, there were 21 U.S.-based companies performing major defense and aerospace work; today there are six U.S.-based major prime contractors: Boeing, Lockheed Martin, BAE Systems (which is a subsidiary of a British firm), Raytheon, General Dynamics, and Northrop Grumman. This consolidation (which also included vertical integration of many subcontractors) also had a broad impact at the lower levels, with many of the remaining suppliers moving much of their business to the commercial sector. These suppliers could no longer rely on the DoD to provide the majority of their business. In many critical defense areas, the number of suppliers remaining—at either the prime contractor or lower tier levels—is down to only one or two. Additionally, during the Cold War, much of America's R&D investment was concentrated on defense. The resultant technologies were then adapted to civilian and commercial applications. This is no longer the case. The entrance of the commercial sector into advanced information technology R&D has created another option for the defense industry to consider when purchasing and adapting systems and technology for military use (i.e., a move from the historic "spin off" of defense technology to a "spin on" of civilian technology into defense).

Additionally, today, technology development and production are globally dispersed. As a result, the United States depends on offshore sources for defense-related technologies (especially in critical, lower tier component areas). Increasing reliance on foreign sources for production has allowed the DoD to achieve higher performance, while reducing costs (thus increasing the number of units produced), and to improve deployment times (Moran, 1990). The use of foreign sources has also allowed for greater competition among firms realizing cost savings for the DoD; however, security risks do exist and must be addressed, and the political stigma attached to the perceived notion of "too much offshoring" continues to attract its fair share of critics.

It is against this backdrop that new challenges have emerged, including, first and foremost, national budgetary constraints. For the foreseeable future, the DoD must anticipate a constrained budgetary environment. In an effort to address the anticipated shortfalls, the DoD has continued to stress the importance of cutting costs by "achieving new efficiencies, eliminating additional duplication and overhead, tightening personnel costs, enhancing contract competition, and reevaluating modernization programs" (Office of the Undersecretary of Defense [Comptroller], 2012, p. 3). The United States is not the only country to suffer the effects of the worldwide

economic downturn. Most NATO countries, for instance, have fallen far short of their commitment to target 2 percent of GDP for defense spending.

The lack of qualified graduates in science, technology, and engineering has begun to erode America's global competitiveness, creating another challenge. While international students certainly contribute to the U.S. economy and educational system, a significant amount of "brain drain" still occurs—that is, an increasing portion of international scientists and engineers will return to their home countries once they complete their education. As they return to their countries of origin (or relocate to other countries where their talents may be more highly valued), the United States loses out on their potential contributions to research and innovation in both the public and private sectors.

Another perceived challenge, "Offshoring" (or outsourcing business functions to companies located in foreign countries), is a politically charged topic that is often blamed for exploitative practices and lost American jobs. There are more than a few critics who have disparaged commercial giants, such as Wal-Mart, that have decided to outsource labor to other countries, allowing them to provide high-quality and less expensive products to their consumers. However, while moving production and manufacturing of goods to (mostly Asian) countries may have moved some jobs away from the United States, IT companies such as IBM, Dell, Cisco, and Apple have also moved significant portions of their businesses outside of the United States, primarily to India and China.

New and evolving security concerns present yet another challenge. Non-traditional adversaries of the U.S. have evolved new tactics that seek to undermine conventional American military dominance. Adequately deterring or combating these new threats will require a greater level of cooperation among states to act jointly against terrorist organization and other non-state actors, and, if need be, against other states. These new, emergent threats include international piracy, chemical and biological weapons and their deployment, nuclear weapons proliferation, and cyber warfare and cybersecurity.

Given these challenges, self-sufficient autarky—that is, non-reliance on outside sources—may seem to be desirable policy; however, given the current environment—that is, domestic

budgetary realities and the pace of foreign technological innovation—protectionist policies are not only unaffordable, but would quickly lead to a reduction in America's military superiority. In fact, today, every U.S. weapons system contains foreign parts—because they are better, not because they are cheaper.

Although a global sourcing and acquisition strategy must be pursued out of necessity, there nevertheless are specific benefits that can be derived by pursuing such a strategy. There are also real risks associated with a global strategy, which we believe can be reduced to acceptable levels.

Defense industry globalization allows the DoD to take advantage of benefits derived from (1) economies of scale, (2) global competition, (3) comparative advantage (i.e., having "best" in class), (4) system interoperability (for coalition effectiveness), and (5) improved foreign relations.

First and foremost, the DoD benefits from economies of scale. Because parts and components can be purchased for less, the DoD can spread the fixed acquisition costs over a larger number of systems. In addition, "learning" occurs along the way which further reduces costs—allowing for far greater production capability and heightened efficiency.

The potential for global competition is another benefit. Simply put, competition allows the DoD to take advantage of the best performance at the lowest cost. Furthermore, the ability to take advantage of global "best of breed" technologies, products, and services offers the opportunity for U.S.-based firms to focus more of their efforts in areas where the United States holds a clear comparative advantage. Additionally, today, the United States and its allies are better positioned to design and produce state-of-the-art ("best in class") technology and systems, in that industry globalization permits access to the latest innovations at the lowest prices. And, global competition forces U.S. firms to innovate (in order to be competitive). Finally, since most of the envisioned future military operations will involve an international coalition, U.S. and allied military systems can be designed to be highly interoperable, providing a key strategic advantage when conflicts arise. These greater ties with foreign firms and nations within the defense arena will also potentially foster goodwill in related areas, such as diplomacy and international policy.

Nonetheless, the advantages afforded by globalization do come with some risk. These include (1) the diffusion of technology, (2) the loss of technical leadership, and even expertise, (3) and the increase in the number of counterfeit parts and components.

Generally speaking, globalization has provided potential adversaries with increased access to sophisticated technologies and sensitive information. However, the solution in this regard is better control of technologies through multilateral agreements with allies. Globalization may also lead to some loss of expertise in production of defense industrial goods. Over time, this could pose a significant problem. To mitigate this risk, the United States must ensure that it retains the ability to design and produce critical technologies. Finally, globalization has fueled the growth of counterfeiting of parts and components, in many industries. The defense industry is no exception. Counterfeit parts can affect the safety, operational readiness, and critical nature of the military mission.

The United States has slowly begun to recognize the benefits of a globalized world. In fact, it is clear that the U.S. defense industrial base has undergone a sea change in its composition, becoming increasingly reliant on international sources for its development, production, and provision. Non-U.S. firms are major players within the U.S. defense industrial base. In fact, in 2012, 20 aerospace and defense firms made the Forbes Global 2000 List of the largest public companies operating in the global market. Eleven of these firms have their headquarters based outside of the United States, including BAE Systems, EADS, and Thales. These firms regularly compete alongside Lockheed Martin, Northrop Grumman, and Boeing for contracts with the U.S. government. Moreover, these companies often work with each other across national boundaries, and almost all have U.S.-based, significant subsidiaries.

No defense program illustrates the role that non-U.S. firms play in developing and manufacturing American weapons systems better than the F-35 Joint Strike Fighter. Nine nations partnered in the F-35's 10-year System Development and Demonstration (SDD) phase: the United States, United Kingdom, Italy, the Netherlands, Turkey, Canada, Denmark, Norway, and Australia (see Figure 11). These nations contributed about $4.5 billion total in cash and in kind, or about 14 percent of total program costs. Additionally, Israel and Singapore agreed to join the program as Security Cooperation Participants, contributing $50 million each. By partnering with

the United States during SDD, firms in these countries could bid for work on a "best value" basis, and participate in the development and acquisition of the aircraft.

The United States must come to realize that defense industry globalization is already underway, and that in order to maximize the associated benefits, the nation must embrace this change in order to focus on some of the associated challenges. There is no alternative. Failure to embrace the globalization of science and technology (S&T) in general, or defense industry globalization in particular, will isolate the United States from the newest developments, the majority of which will soon occur in other countries. In order for the DoD to shape and take advantage of the technologies of tomorrow, it should embrace industry globalization by relying on the best technologies available, allowing foreign access to certain American technologies, and building partnerships within the global S&T community.

It is clear that business has already determined that the defense market should be completely globalized. Many leading defense firms with a presence in the United States are majority foreign-owned, and (and as noted above) many of them have U.S.-based subsidiaries, with special security boards" designed to mitigate risks, real and perceived, that are associated with foreign contracting. However, U.S. defense policy does not embrace this new reality (i.e., that defense industrial base globalization is already well underway). Denying its reality, or insisting that the United States could just as easily pursue a protectionist policy, is counterproductive, especially in light of the security, budgetary, and other emerging challenges.

# I. Introduction

In April 2013, the Pentagon acknowledged that it had leased a Chinese satellite to provide urgently needed communications capabilities for its Africa Command. The DoD has stated that the Chinese satellite provides "unique bandwidth and geographic requirements" that other satellites do not (Congressional China Caucus, 2013). China is Africa's largest trading partner, and Chinese companies (Huawei and ZTE, in particular) have invested significantly in the continent's infrastructure; the construction of an advanced communications satellite is but one investment among many. From an economic standpoint, the arguments in favor of the United States leasing the Chinese satellite are clear: It provides superior performance that cannot be easily obtained from other providers, and it was readily available in a time of urgent need.

However, many within Congress are worried, and perhaps rightly so, that the Chinese might be able to decode encrypted U.S. communications. But this was not their only concern. Representative Mike Rogers of Alabama wrote that the move "sends a terrible message to our industrial base at a time when it is under extreme stress" from recent military budget cuts (Capaccio, 2013, p. 1). And, Representative John Garamendi of California stated that the lease confirms his suspicion that there is a pronounced lack of coordination among Pentagon officials who oversee intelligence, surveillance, and reconnaissance systems (Capaccio, 2013, p. 1).

Objections of this nature are voiced repeatedly within American defense circles, wasting valuable time and resources. And, they are bound to continue because current U.S defense industrial policy does not address today's technology and industrial globalization or its implications. Because there is no agreed-upon point of reference, Congress, industry, and the public regularly scrutinize DoD decisions to buy or lease foreign systems, collaborate on projects with oversees partners, or share technology with allies, regardless of the details. However, globalization of the defense industry is already well underway and largely irreversible. Some might be surprised to learn that every U.S. weapons system contains foreign parts. To be sure, there are risks associated with globalization, especially within the context of national defense, which is precisely why the United States must pursue a defense industrial policy that anticipates, rather than reacts to, the expansion of global trade and technological innovation.

The nation's military strategy, in large part, continues to depend on superior technology, highly qualified operational forces, and the ability to sustain those forces, in order to achieve its objectives. However, the global industrial base, as well as the U.S. industrial base, has changed significantly since the end of the Cold War era; yet, current U.S. policy amounts to little more than the consolidation of numerous incremental changes that are often contradictory in their aims. The impacts of globalization on defense must be better understood, so that policy-makers can better balance the requirements of defense industrial and trade policy with political, economic, and security considerations. By embracing the advantages afforded by globalization, and guarding against its adverse consequences, the U.S. military can maximize efficiency and effectiveness in order to promote stability in an ever-changing world.

## *Report Roadmap*

This report describes the impacts of globalization within the context of the defense industry. In Part II, we provide a brief description of the U.S. defense industrial base during the Soviet era. We then describe some of the global forces that have ushered in tremendous change. In Part III, we discuss today's environment, which is characterized by a shrinking domestic defense budget, global economic interconnectedness, the foreign manufacture of defense products, along with U.S. domestic manufacturing by foreign-owned firms, and new national security concerns. Next, in Part IV, we discuss both the advantages (e.g., economies of scale, international competition, enhanced security) and risks (e.g., increased diffusion of technology and counterfeit parts) of defense industry globalization. In Part V, we cite examples of how defense industry globalization has begun to manifest itself. In particular, we describe the F-35 program, a collaborative effort with international partners to design and manufacture the next air-superiority fighter. We also discuss America's increasing reliance on foreign components and systems (e.g., in the Mine-Resistant Ambush-Protected [MRAP]). Finally, in Part VI, we discuss some of the challenges that the United States must confront, namely achieving strategic and technical interoperability with allies, and maintaining competency in the fields of S&T.

# II. Background

*"God did not bestow all products upon all parts of the earth, but distributed His gifts over different regions, to the end that men might cultivate a social relationship because one would have need of the help of another. And so He called commerce into being, that all men might be able to have common enjoyment of the fruits of the earth, no matter where produced."*

—*Libanius (AD 314–393),* Orations (III)

## *Globalization Defined*

Globalization is the long-term, largely irreversible phenomenon involving the political, cultural, and economic merging of geographically dispersed groups of people across geopolitical lines (DSB, 1999). The term globalization was first described as an unstoppable process 30 years ago (Levitt, 1983), but the concept of globalization is not a new one. In fact, the ancient Greek rhetorician Libanius believed globalization was both necessary and inevitable (see quotation above). For centuries, commercial entities have taken advantage of ever-widening circles of trade and interconnected markets in an effort to increase their dominance. This tendency, toward the transcendence of national boundaries and the interconnection of markets for goods, services, and capital, is sometimes overlooked. It is common knowledge that Detroit's automakers pioneered assembly-line car production in the early 1900s, but what is less well known is that both Ford and General Motors were assembling cars in 24 countries by 1928 (Sturgeon & Florida, 2000).

With the advent of modern transportation and communication technologies, the implications of globalization have grown exponentially. The ramifications of globalization are especially helpful in explaining the complicated interaction between the current practices of the defense industrial base in the United States and existing U.S. defense industrial policy. No longer an abstract concept, the implications of this phenomenon pervade all aspects of modern society.

Globalization accelerated with the end of the Cold War. The spread of capitalism and reduced barriers to trade enabled the rapid and global movement of capital. In recent decades, the information revolution has accelerated the pace of globalization, reducing "barriers of physical

distance, blurring national boundaries and creating cross-border communities of all types" (DSB, 1999, p. 5).

### *Peace Dividend*

The end of the Cold War brought decreased defense spending (a 36 percent decline in the defense budget from 1988 to 2000), along with a proportional drop in U.S. troop levels. This new level of spending forced a major restructuring of the nation's defense industry in the 1990s.

In the past, the U.S. industrial base (commercial and defense) would ramp-up production to meet the needs of the U.S. military and then fade into the background when the conflict concluded. Throughout the Cold War, however, defense emerged as a permanent segment of America's industrial base, providing dedicated development and production of systems, equipment, and supplies. Rather than mobilize for conflict, the military sought to develop sufficient permanent capacity within the defense industry to successfully engage in conflicts as they arose (Gansler, 1980). To this day, the nation's military strategy, in large part, continues to depend on superior technology, highly qualified operational forces, and the ability to sustain those forces.

Today's industrial base no longer exists in its Cold War form. The end of military tensions between the former Soviet Union and the United States ushered in a major restructuring of the defense industry. Four major developments precipitated a new environment in which the post–Cold War defense industrial base now operates: (1) major cuts to the defense budget, (2) the commercial sector entrance into high-tech research and development (R&D), (3) the offshoring of technology R&D and production, and (4) the DoD's shift towards net-centric warfare, a strategy informed by the increasingly sophisticated and complex communications and information technology becoming available.

A string of defense firm mergers in the 1990s resulted in major industry consolidation: The number of major U.S.-based defense and aerospace companies shrunk from 21 in 1993 to less than half that number today. In 1993, there were 21 U.S.-based companies performing major defense and aerospace work; today there are six U.S.-based major prime contractors: Boeing,

Lockheed Martin, BAE Systems (which is a subsidiary of a British firm), Raytheon, General Dynamics, and Northrop Grumman.

This consolidation (which included considerable vertical integration—with the primes absorbing many of the suppliers) also had an impact at the lower levels, with many of the remaining suppliers moving much of their business to the commercial sector. These suppliers could no longer rely on the DoD to provide the majority of their business. In many critical defense areas, the number of suppliers remaining—at either the prime contractor or lower tier levels—is down to only one or two. With the projected decline of the defense budget through 2021, this consolidation trend may increase.

### *Commercial Sector Entrance into Technology R&D*

Prior to and during the Cold War, much of the U.S.'s R&D investment was concentrated on defense. The resultant technologies (e.g., jet propulsion, satellites, computers, etc.) were then adapted ("spin off") to civilian and commercial applications. The end of the Cold War was coincident with the start of the information revolution, and research investments began to focus on commercial applications. There was also a significant increase in the global investment in research, so that now it is greater than the total U.S. investment (see Figure 1).

| | Cold War (1965) | End of Cold War (1993) | 2009 |
|---|---|---|---|
| U.S. Government | $60B | $75B | $80B |
| U.S. Commercial | $90B | $200B | $300B |
| Rest of World | Unknown | $300B | $450B |

**Figure 1. R&D Investment**
(*Note*: The information in this figure comes from the Army Science Board, 2013)

The entrance of the commercial sector (which pays little attention to national boundaries) into advanced information technology R&D has created another option for the defense industry to

consider when purchasing and adapting systems and technology for military use. In 1999, the Defense Science Board (DSB) concluded that

> The commercial sector, which pays scant attention to national boundaries, is now driving the development of much of the advanced technology integrated into modern information-intensive military systems. This is especially true of the Software and consumer microelectronics sectors. Accordingly, U.S. military-technological advantage will derive less from advanced component and subsystem technology developed by the U.S. defense sector than from the military functionality generated by superior, though not necessarily U.S.-based, defense sector systems integration skills. (DSB, 1999, p. 8)

Today, the commercial sector continues to invest heavily in developing and advancing technologies, often outpacing similar work performed by the defense industrial base. The availability of high quality, commercial-off-the-shelf (COTS) hardware and software has netted significant savings to the DoD, in terms of systems development and maintenance (McKinney, 2001). It is clear that the vector of technology transfer has reversed, and defense increasingly strives to adapt the latest commercial developments and products.

## *Foreign Production and Manufacture of Defense Goods*

Today, technology development and production are globally dispersed. As a result, the United States depends on offshore sources for defense-related technologies (especially in critical, lower tier component areas). Increasing reliance on foreign sources for production has allowed the DoD to reduce costs, increase the number of units produced, and improve deployment times (Moran, 1990). The use of foreign sources has also allowed for greater competition among firms, resulting in improved performance and cost savings for the DoD; however, security risks do exist, and the political stigma attached to the perceived notion of "too much offshoring" continues to attract its fair share of critics.

## *From Traditional Weapons to Networked Systems*

The Information Age has ushered in rapid advances in technology. As a result, the information available and subsequently required by U.S. forces has grown significantly in volume and has become more specific and more diverse (Alberts, Garstka, & Stein, 2000). The term *network centric warfare* (NCW) emerged to describe the translation of information superiority into

combat power through the effective linking of "knowledgeable entities" within a given battlespace (Alberts et al., 2000). This linking or "networking" of virtually all battlefield entities has served to accelerate "engagement cycles and operational tempo at all levels of the warfighting system" (Kopp, 2005, p. 3). NCW offers many advantages over traditional warfighting methods. First, individual assets are able to access information in real time without having to navigate through disparate and disconnected information conduits, allowing them to more quickly assess and respond to situations. Second, complete battlefield awareness, along with advances in precision munitions, allow for far more accurate fire placement. Third, seamless information flow allows units to act as a cohesive whole, even when assets are geographically dispersed.

# III. Current Environment

In addition to the changes that resulted from the end of the Cold War, today's environment presents many challenges for the nation's defense industry, and for national security writ large. The following issues are highlighted to demonstrate why the transition to a globalized defense industrial base is not only inevitable, but largely positive.

## *New Budget Reality*

The first decade of the 21st century saw a sharp increase in defense spending, brought on by the terrorist attacks of September 11, 2001, and the subsequent military operations in Iraq and Afghanistan. Late in 2007, the U.S. housing market collapsed, leading to a global financial crisis and an extended recession. At the current rate, the U.S. deficit is projected to exceed the nation's GDP by the early 2020s (Congressional Budget Office [CBO], 2010). In fact, it is projected that mandatory federal spending (on healthcare, social security, income security programs, federal and military retirement benefits, and veterans' benefits) and interest payments will exhaust the entire federal budget by 2036, if current trends in spending and demographics continue (Center for Strategic International Studies [CSIS], 2013).

As a result of the ending of contingency operations, and in response to the budgetary pressures, the DoD's future budget is expected to decline significantly (by approximately 31 percent) over the next eight years (see Figure 2). In the past, the DoD could rely on personnel reductions in order to constrain costs. Today, however, the active military force structure is already near an all-time low (as also seen in Figure 2); thus, apart from some small, further reductions in troop end-strength, significant reductions are unlikely. Additionally, the Budget Control Act of 2011 (Pub. L. 112–25, enacted August 2, 2011) introduced budget sequestration—that is, automatic cuts imposed because deficit reduction targets were not met.

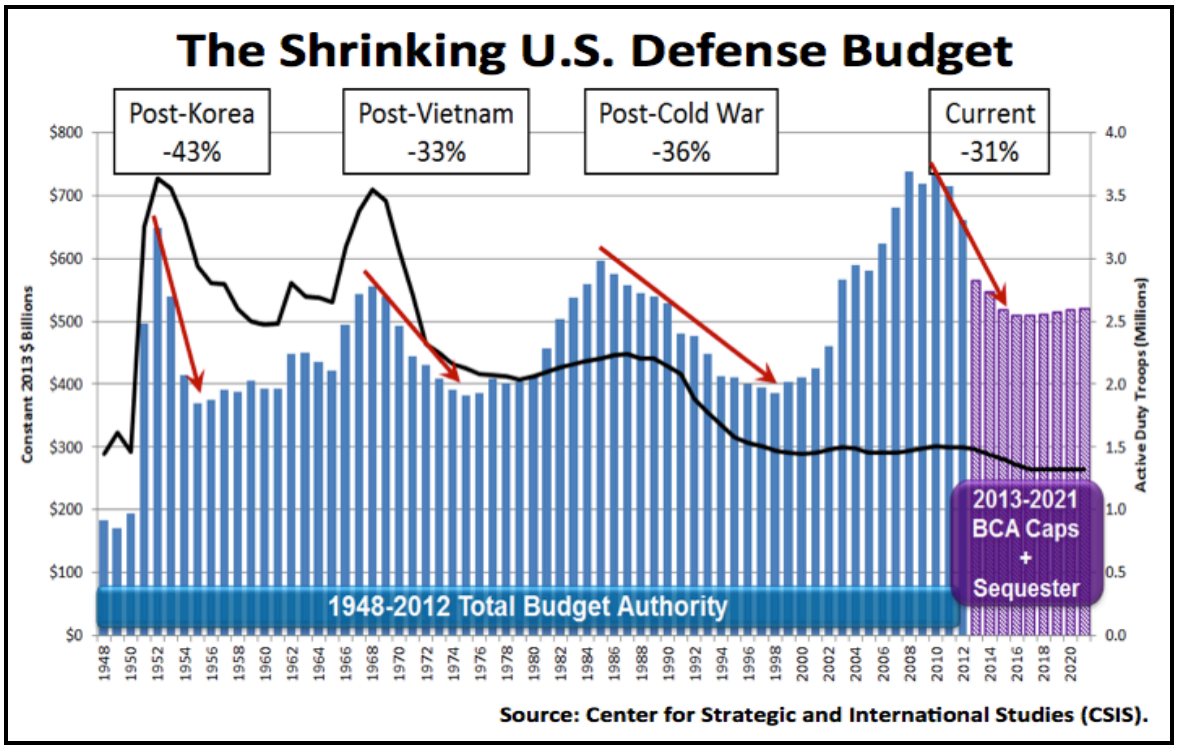


**Figure 2. The U.S. Defense Budget and Active Duty Troop Levels, 1948-2021** (CSIS, 2013)

Against a backdrop of declining resources, the DoD will see substantial growth in the cost of operations and maintenance. A significant portion of that growth can be attributed to the cost of military personnel. During Operation Iraqi Freedom and Operation Enduring Freedom, military salaries grew significantly; in fact, military personnel costs have doubled since 2001 (about 40 percent above inflation). Note that during this time the number of full-time military personnel only increased by approximately 8 percent. When supplemental funding is excluded, personnel costs increased by nearly 90 percent, or about 30 percent above inflation, while the number of military personnel increased by only about 3 percent (DoD, 2012). Figure 3 shows the increasing O&M spending and the projected shortfalls, based on CBO projections.

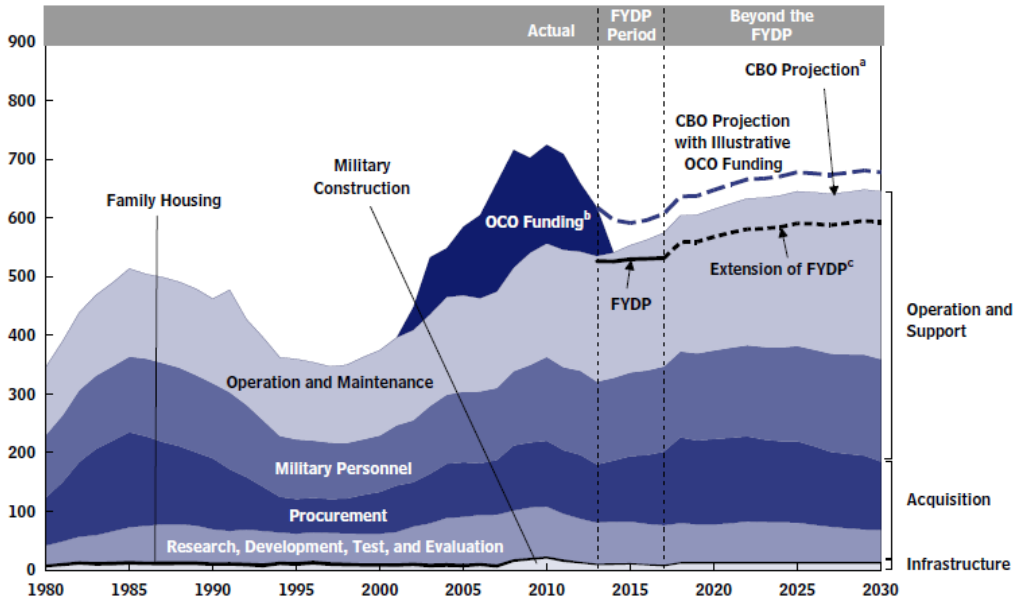


**Figure 3. Costs of DoD's Plans by Appropriations Category (Billions of 2013 Dollars)** (CBO, 2013)

The DoD has been focused on the problem of rising costs for some time. Senior leadership has undertaken a number of initiatives in an effort to address fiscal challenges and rescale operations. Former Secretary Robert Gates and Secretary Leon Panetta developed plans to cancel several major programs and introduced several other initiatives to improve efficiencies (Harrison, 2011). However, historically, savings initiatives have realized only a fraction of what was projected.

For the foreseeable future, the DoD must anticipate a constrained budgetary environment. In an effort to address the anticipated shortfalls, the DoD has continued to stress the importance of cutting costs by "achieving new efficiencies, eliminating additional duplication and overhead, tightening personnel costs, enhancing contract competition, and reevaluating modernization programs" (Office of the Under Secretary of Defense [Comptroller], 2012, p. 3).

The United States is not the only country to suffer the effects of the worldwide economic downturn. Most NATO countries, for instance, have fallen far short of their commitment to target 2 percent of GDP for defense spending (see Figure 4). "We are moving toward a Europe that is a combination of the unable and the unwilling," said Camille Grand, a French military expert who directs the Foundation for Strategic Research (Erlanger, 2013).

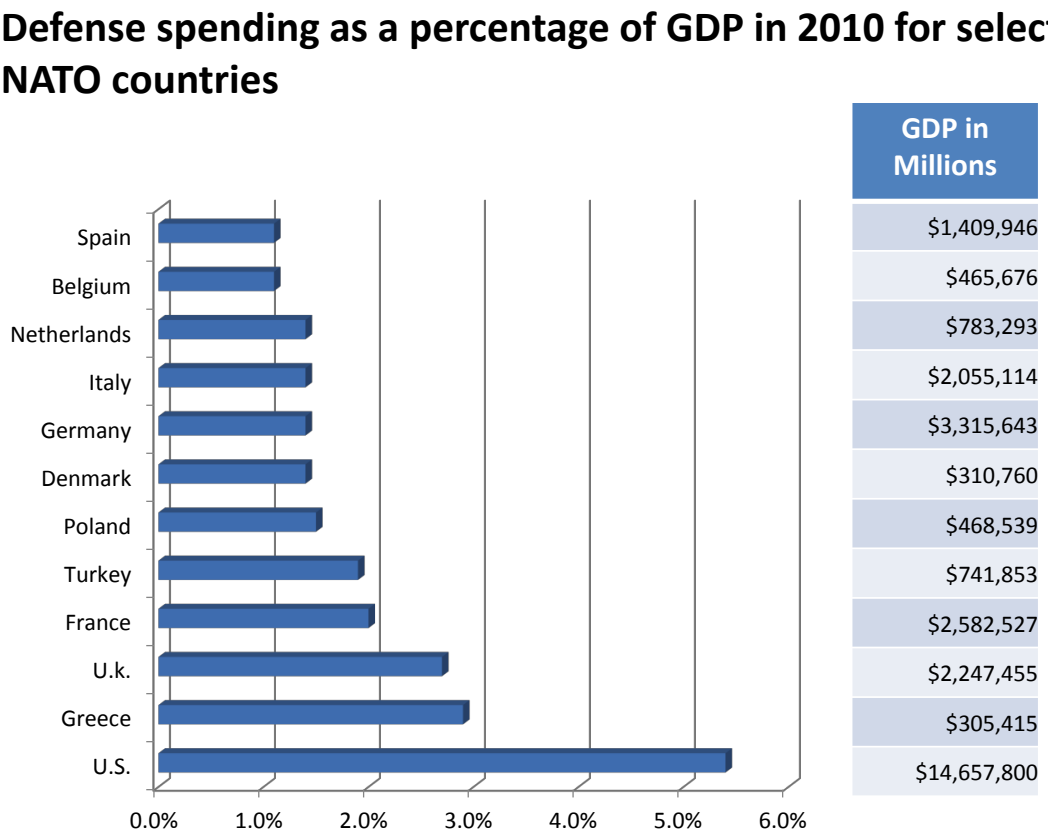


**Figure 4. NATO Defense Spending, 2010** (NATO, 2011)

In this era of decreasing defense budgets, the United States and their NATO allies must leverage the globalization trends to be able to afford the quantity and quality of weapons systems they require to meet future needs.

## *A Rapidly Changing, Globalized World*

The impacts of globalization cannot be overstated. These impacts manifest themselves in significant ways. Below, we discuss the revolution in communication technologies that has resulted in an essentially "borderless" world, an education system characterized by a significant international population, the inextricable interconnectedness of the global economy, and heightened concerns about national security and technology.

### Advances in Technology and Weakened Geopolitical Boundaries

New information technologies now allow for the relatively low-cost and, in many cases, instantaneous transfers of large amounts of information. These global information capabilities enable inexpensive, instantaneous communications, reducing the cost of transactions and making it possible to conduct and maintain personal and business relationships around the world. When coupled with the improvements in transportation, physical borders no longer pose a barrier to interactions among various citizenries. Of course, geographic borders still exist, but physical borders can no longer isolate a population as they once did (except perhaps in extremes cases—e.g., North Korea). In most cases, borders are porous to some degree—citizens pass from one country to another with ease (as in the case of those living within the European Union member states). Weakened geopolitical boundaries allow U.S. adversaries to exploit the best commercial technologies developed globally, and, since the DoD cannot compete solely through internal investments, it must do the same.

### Broadened Cultural Identity and Increased Educational Exchanges

A complicated global citizenry now exists. Loyalties may be split because of ties to multiple nations—due to family, work, and (dual) citizenship. Foreign nationals are able to travel to the United States more easily, just as U.S. citizens may go abroad with ease as well. As a result, foreign nationals often pursue visas to work and attend school in the United States, which, despite the rising cost of tuition, continues to offer superior, perhaps unrivaled, education, especially in the science and technology fields. While it is clear that these foreign students (and their home countries) clearly benefit, so, too, does the United States. Students from around the world who study in the United States contribute to America's scientific and technical research and bring international perspectives into U.S. classrooms, which helps prepare American undergraduates for global careers and often leads to longer term business relationships and economic benefits (Institute of International Education, 2012). The number of foreign students enrolled in institutions of higher education in the United States increases every year (see Figure 5).

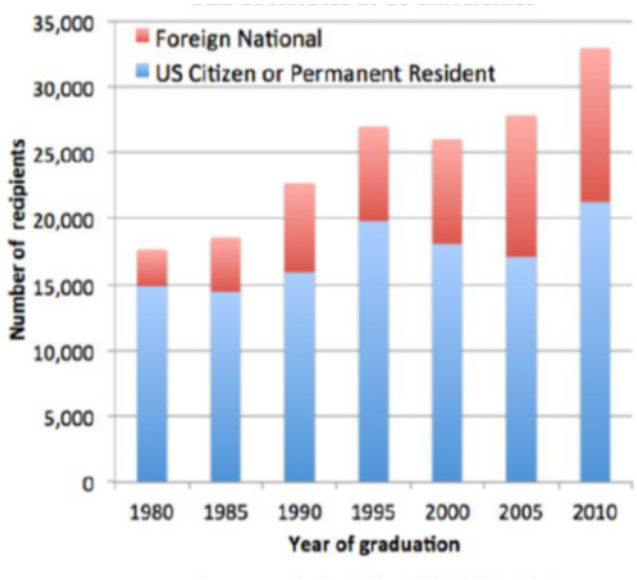


**Figure 5. Citizenship Status of Recipients of S&E Doctorates at U.S. Universities** (Army Science Board, 2013)

The following statistics help to illustrate the extent to which international students studying in the United States contribute to higher education and the U.S. economy:

- During the academic year (AY) 2011–2012, there were 764,495 international students studying at U.S. colleges and universities.
- This represents a six percent increase from the previous year, AY2010–2011.
- In AY2011–2012, international exchange contributed $22.7 billion to the U.S. economy (Institute of International Education, 2012).
- China, India, and South Korea send the largest number of students to study in the United States, with China sending about one-quarter of the U.S. international student population.
- About 36 percent of the international students are studying in the science, technology, mathematics, and engineering (STEM) fields.

Although international students certainly contribute to the U.S. economy and educational system, a significant amount of "brain drain" still occurs. An increasing portion of these international scientists and engineers will return to their home countries once they complete their education. As they return to their countries of origin (or relocate to other countries where their talents may be more highly valued), the United States loses out on their potential contributions to research

and innovation, in both the public and private sectors. Of those foreign nationals holding H-1B visas (which allow employers to temporarily hire foreign workers for specialty occupations), only 7 percent are cleared to become permanent residents. It has been suggested that the United States should move to a system similar to that of the United Kingdom and Canada, which favor admitting immigrants who have advanced science and technology degrees (Gansler, 2011).

Despite recent gains, the number of STEM graduates in the United States, the European Union (EU), and Japan continues to lag behind China.. However, some are skeptical of the quality of Chinese degrees, especially in science and engineering fields. Nevertheless, it appears that China continues to threaten U.S. dominance (see Figure 6).

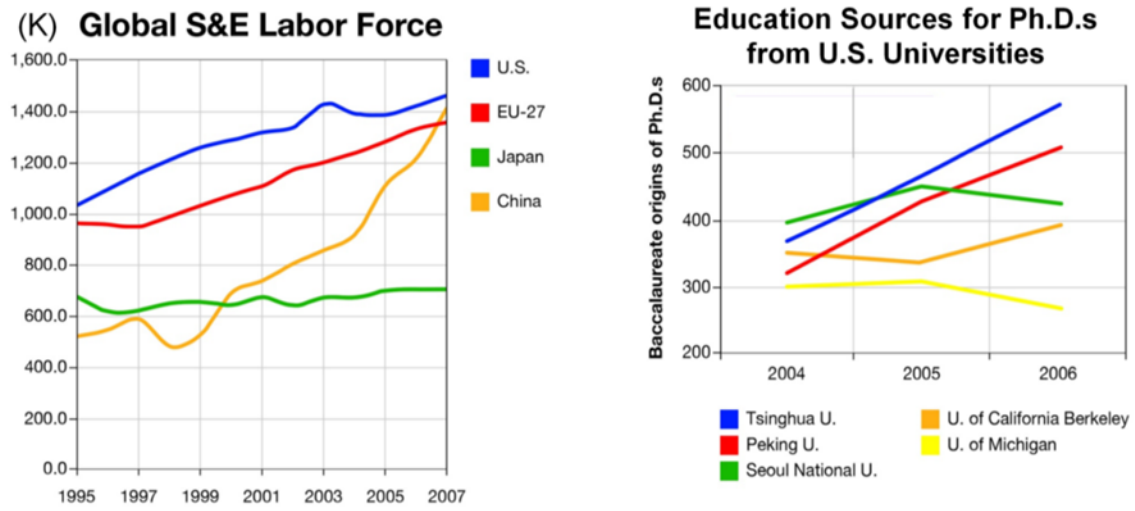


**Figure 6. The R&D Environment: Last 50 Years** (Army Science Board, 2013)

Note that the chart on the right indicates that among students with PhDs from American universities, more received their baccalaureate degrees from either a Chinese or South Korean university than from either of the two American universities that graduate the largest numbers of baccalaureate degrees in the United States.

In order to remain competitive with emerging economic powers, U.S. industry will need to leverage U.S.-educated foreign STEM workers. These workers are not only highly skilled, but are often highly motivated by their desire to gain permanent U.S. residency. Accordingly, they

are often willing to work at lower wages (compared with their American-born counterparts), thereby increasing America's global competitiveness. Scholars agree that countries such as China and India are benefiting from their citizens receiving postsecondary education in the United States and then returning to their countries of origin after receiving their degrees.

### Economic Interconnectedness among Industry and Nation-States

Corporations are increasingly multinational in orientation. According to the United Nations International Labour Organization (ILO), there are approximately 50,000 multinational enterprises (MNEs) with 450,000 affiliates (ILO, 2013). These MNEs employ over 200 million people throughout the world. Long before the defense industry began to shift from domestic autarky to making use of international goods and services, the commercial sector had been making use of more efficient and higher quality production and manufacturing processes, conducted outside of the United States.

"Offshoring" (or outsourcing business functions to companies located in foreign countries) is a politically charged issue that is often blamed for exploitative practices and lost American jobs. There are more than a few critics who have disparaged commercial giants, such as Wal-Mart, that have decided to outsource labor to other countries, allowing them to provide high-quality and less expensive products to their consumers. However, while moving production and manufacturing of goods to (mostly Asian) countries may have moved some jobs away from the United States, the "Wal-Mart Effect" is also credited with keeping U.S. inflation in check throughout the last two decades (Preston, 2013).

After the success of Wal-Mart, information technology companies saw the significant economic benefits to be had in initiating a global supply chain. IT companies such as IBM, Dell, Cisco, and Apple have moved significant portions of their businesses outside of the United States, primarily to India and China. Due to conscious efforts on Dell's part to publicize the fact, the efficiencies of Dell's global supply chain are inextricably linked to the quality of its products and services now (Preston, 2013).

Other companies like IBM have been more reluctant to publicize their global workforce. Of the approximately 430,000 employees working for IBM, less than a quarter are located in the United States. In fact, it is estimated that the number of IBM employees in India exceeds 110,000 (Thibodeau, 2012).

Due to the economic interconnectedness of private business worldwide and initiatives by various governments and economic alliances, treaties have been created to promote mutually beneficial international trade policies among member states. The World Trade Organization, the G8, and the G-20 are all groups dedicated to managing some aspect of the world economy through joint multinational efforts. Additionally, the North American Free Trade Alliance (NAFTA) and the Organization of the Petroleum Exporting Countries (OPEC) are both examples of this move toward some level of economic integration among nation-states. The EU represents perhaps the highest level of economic alliance among states, though lately the virtue of this may have been called into question, given the current economic crises in Greece, Cyprus, and other Mediterranean countries.

## *New and Evolving Security Concerns*

The networks and technologies that have advanced globalization have, at the same time, enhanced the scope and reach of irregular security threats. These create an opportunity for the non-traditional adversaries of the United States to offset conventional American military dominance. To adequately deter or combat these new threats will require a greater level of cooperation among states to act jointly against terrorist organization and other non-state actors, and, if need be, against other states. These new, emergent threats include the following.

### International Piracy

Piracy has existed for almost as long as there has been travel by sea, but the response to international piracy on a multilateral front has resulted from the increased international trade brought about by globalization. The International Chamber of Commerce (ICC) established the International Maritime Bureau in 1981 and the IMB Piracy Reporting Centre in 1992. Based in Kuala Lumpur, Malaysia, the purpose of the Centre is to keep constant surveillance on the world's shipping lanes, issue warnings about "hotspots" for piracy, and report attacks to local

law enforcement (ICC-CCS, 2013a). The increased traffic of ships due to global trade presents a tempting opportunity to pirates. For example, between January and May 2013, there were 100 reported incidents of piracy (including four hijackings). Shipping lanes within such places as the Gulf of Aden and the Straits of Malacca have been the sight of multinational efforts attempting to prevent the hijacking of cargo ships (ICC-CCS, 2013b).

### Chemical and Biological Weapons Development and Deployment

The dissemination of information required to develop and deploy chemical and biological weapons has increased dramatically with globalization. Fear of chemical weapon use on combatants engaged in international conflict led to the 1925 Geneva Protocol banning their use in combat. In 1975, the Biological Weapons Convention (BWC) was the first disarmament agreement to provide for the elimination of an entire category of weapons of mass destruction under universally applied international control (United Nations Office for Disarmament Affairs 2013a). And, in 1992, the Chemical Weapons Convention (CWC) became the first disarmament agreement negotiated within a multilateral framework UNODA, 2013b).

In today's globalized world, where transportation is inexpensive and borders are easily crossed, the material to develop weapons, or the weapons themselves, can proliferate. Moreover, there is the threat of non-state (terrorist) actors acquiring these weapons. This potential threat from chemical and biological weapons pushes nations to collaborate to eliminate the capability and destroy the capacity of others to produce and utilize them. In cases where the possession or use of chemical and/or biological weapons is suspected, international intervention is required.

### Nuclear Weapons Proliferation

Similarly, the proliferation of weapons and military technology has become easier, due to globalization, and it has become easier for geographically dispersed "rogue" states to ally with one another. The case of North Korea and the Middle East offers a good example:

> Since the 1960s, North Korea's [weapons] sales have run the gamut, from conventional weapons, to increasingly sophisticated, longer-range missiles, to collaborating with Syria on the construction of an entire clandestine nuclear reactor with no evident purpose except to produce plutonium for nuclear weapons. Among North Korea's many clients over the years have been Egypt, Yemen, Syria, Pakistan, Iraq under Saddam Hussein, and

> Libya under Muammar Qaddafi, as well as Iran, and Iran's satellite Lebanese terrorist organization, Hezbollah. (Rosett, 2013)

### Cyberwarfare and Cyber Security

In a globalized world, physical threats are not the only issue of concern for nations. Along with the positive developments in information systems technology and communication that have improved the lives of millions, the weaponization of telecommunications technology may create significant problems for national security. Cyberspace has become the "fifth domain" of modern warfare (The Economist, 2010). This rise in cyberwarfare and cyber-attacks has led to the advent of the cyber security field. The United States government (as well as private sector firms and other governments) operates under constant threat of cyber-attack. The DoD is a particularly attractive target. General Alexander, Commander of the U.S. Cyber Command, highlighted the extent of the military's computer systems: "more than 7 million machines, linked in 15,000 networks, with 21 satellite gateways and 20,000 commercial circuits composed of countless devices and components." He went on to assert that these systems are probed 250,000 times an hour, or more than 6 million times a day, by unauthorized users. He concluded by expressing concern about the wide array of threats to DoD's network security, ranging from foreign actors, terrorists, and criminal groups, to individual hackers (Miles, 2010). In response to these threats, the U.S. Cyber Command (CYBERCOM) will increase its workforce by 500 percent between 2014 and 2016 (Ungerleider, 2013).

# IV. Defense Industry Globalization: Benefits and Risks

At first glance, self-sufficient autarky—that is, non-reliance on outside sources—may seem an acceptable, if not desirable, policy, especially within the context of national defense. Given the current environment—that is, domestic budgetary realities and the pace of foreign technological innovation—protectionist policies are not only unaffordable, but would quickly lead to a reduction in America's military superiority. Although a global sourcing and acquisition strategy must be pursued out of necessity, there are nevertheless specific benefits that can be derived by pursuing such a strategy. There are real risks associated with a global strategy, which we believe can be reduced to acceptable levels. Below, we discuss these benefits and risks, as well as risk-mitigation strategies.

## *Benefits*

Defense industry globalization allows the DoD to take advantage of benefits derived from (1) economies of scale, (2) global competition, (3) comparative advantage (acquiring "best in breed"), (4) system interoperability, and (5) improved foreign relations.

### Economies of Scale

First and foremost, economies of scale—the cost advantages of acquiring increased quantities, since the cost per system generally decreases, as the fixed costs are spread out over the increased number of systems produced, and as "learning" reduces costs—allow for far greater production capability and heightened efficiency. Affordability is now a critical attribute, with the ever-increasing cost of cutting-edge weapons systems. For example, as Norman Augustine (1984) pointed out in the 1980s, the cost of fighter aircraft has increased logarithmically over time. As systems become more expensive, the inclination is to acquire a smaller quantity. However, when it comes to cost-performance trade-offs, the calculus is not so straightforward. In 1916, Frederick Lanchester (1916) theorized that the power of a military force is related to the capability of its individual weapons, but proportional to the square of the number of its units. In theory, then, a force of 15 pieces of artillery will have, not a threefold, but a nine-fold advantage (in terms of relative effectiveness) over a force consisting of five pieces. Even within the context of modern

warfare, technical superiority cannot compensate for an insufficient quantity of weapons systems.

Given the DoD's budgetary outlook, reducing the unit cost is critical (in order to achieve the required quantities at lower unit costs). Achieving economies of scale by increasing the number of buyers (i.e., America's international allies) of a military system can drive down the unit cost. On the other hand, by pursuing a protectionist acquisition strategy, the United States risks much higher weapons system acquisition costs, and thus a reduced number of units available, in addition to delayed deployment due to inefficiencies, not to mention reduced or unacceptable performance (Moran, 1990).

### Global Competition

The potential for global competition is another benefit. Simply put, competition allows the DoD to take advantage of the best performance at the lowest cost. Many programs have already leveraged the benefits that derive from global competition. In 2001, Congress authorized the Air Force to lease 100 KC-767 tankers from Boeing for six years starting in 2006 (Government Accountability Office [GAO], 2003). However, this agreement was nullified amidst allegations of improper dealings between Boeing and Air Force officials. In 2011, after a series of missteps by Air Force acquisition personnel, which resulted in a protest (initiated by Boeing) and a canceled contract (awarded to EADS), the Air Force finally contracted with Boeing to purchase the aircraft outright.

The cancellation of the original, sole source lease proved fortuitous, as did the subsequent cancellation of the contract with EADS. As the graph below illustrates (Figure 7), each cancellation effectively spurred a new round of competitive bidding. It has been argued that the transaction costs of managing the relationship between government buyers and contractors can be significant. It is clear that arranging the bidding process, initiating requests for proposals, negotiating with potential bidders, selecting potential contractors, and enforcing the terms of the contract all incur transaction costs. But these costs pale in comparison to the savings that can be achieved through competition. In the case of the KC-767, competitive bidding saved the Air Force over $16 billion.

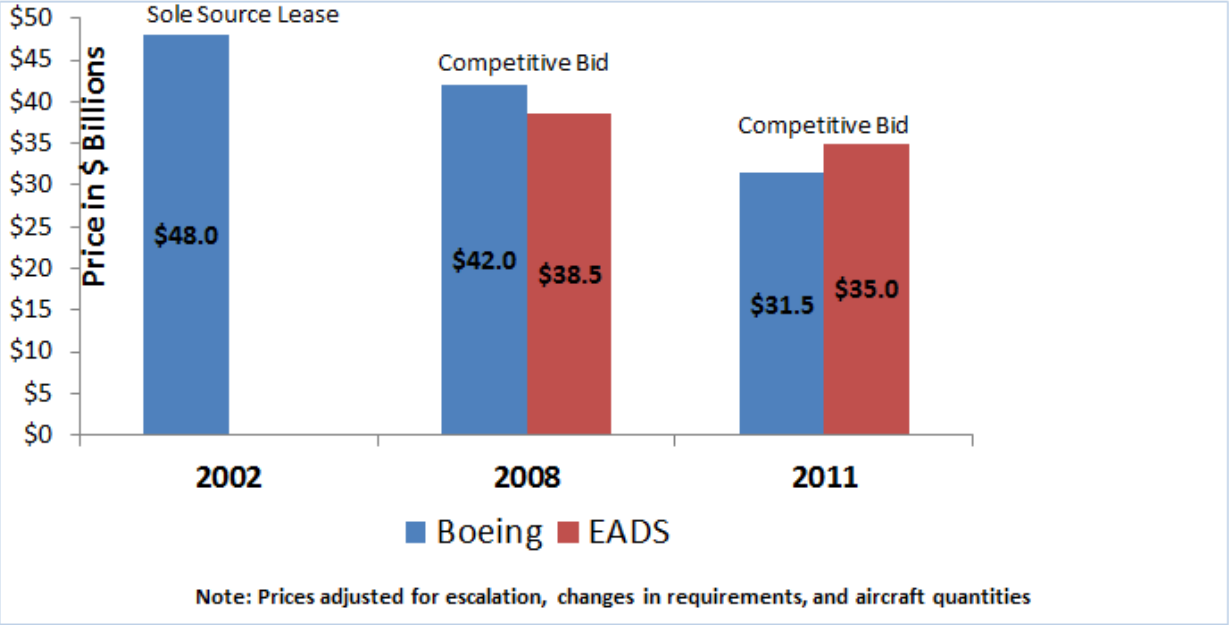


**Figure 7. KC-X Bid History**

## Comparative Advantage

Globalization offers other advantages. The ability to take advantage of global "best of breed" technologies, products, and services offers the opportunity for U.S.-based firms to focus more of their efforts in areas in which the United States holds a clear comparative advantage. However, this advantage is not guaranteed to endure. The DoD must take steps to protect basic and applied research, despite a significantly constrained fiscal environment, in order to ensure the military's technological edge. Fortunately, the FY 2014 DoD budget request notes that the current administration will continue to emphasize a strong national investment in R&D, especially S&T.

## System Interoperability

In addition to purely economic concerns, there are significant security benefits that can be captured as a consequence of globalization. Today, the United States and its allies are better positioned to design and produce state-of-the-art ("best in class") technology and systems, in that industry globalization permits access to the latest innovations at the lowest prices. Since most of the envisioned future military operations will involve an international coalition, U.S. and allied military systems can be designed to be highly interoperable, providing a key strategic advantage when conflicts arise.

### Enhanced Foreign Relations

Additionally, greater economic ties with foreign firms and nations within the defense programs will potentially foster goodwill in related areas, such as diplomacy and international policy. The Joint Strike Fighter program serves as one example. Sharing design and development costs, providing training, and sharing facilities and technologies enhances relations and increases capabilities to respond successfully to threats.

Shared technologies and shared training for utilization of these advanced systems between partner nations also fosters trust. The F-35 program, described in some detail in Part V, provides partner nations the training equivalent to U.S. pilot training. Given past U.S. combatant commanders' concerns regarding gaps in coalition partners' capabilities, the F-35 program provides an opportunity for improved joint military effectiveness as a result of the interoperability of systems and personnel training between partner nations. The ability of partner militaries to train and fight together on the same aircrafts, using the same tactics and procedures, will strengthen both of the individual nations' militaries because they learn from one another, and will strengthen the coalition forces. The Italian Air Force plans to train around 180 pilots and about 1,800 maintainers from now through 2026 (Wright, 2010). Australia expects to start training pilots and maintenance personnel in 2014–2015, when their first two planes are delivered to a U.S. training facility. As of June 2013, the Danish Air Force has sent an F-16 pilot and maintenance personnel to Edwards Air Force Base in California. The joint service partners at Eglin Air Force Base have flown 2,292 F-35 hours and have 28 aircraft assigned, representing the largest fleet of F-35s in the world (F-35 Lightning II, 2012). Fifty-three pilots and 857 maintainers have been qualified through the F-35 training process to date (Roganov, 2013).

In addition to building upon long-time relationships with traditional allies, like NATO countries and Australia, the F-35 program enhances opportunities to build on newer relationships with Israel, Spain, and Asian nations. For example, India and the U.S. have begun to send military personnel to one another's professional military education and development schools to enhance the understanding of their counterparts (DoD, 2011). Japan and South Korea have also expressed interest in purchasing the F-35, which could strengthen long-term economic and military ties and allow the United States to counter China's growing influence in Southeast Asia, including

influence inside the Asia Economic Cooperation (APEC) and the Association of Southeast Asian Nations (ASEAN).

## *Risks*

The advantages afforded by globalization do come with some risk. These include (1) the diffusion of technology, (2) the potential loss of domestic technical expertise, and (3) the increase in the number of counterfeit parts and components.

### Diffusion of Technology

Generally speaking, globalization has provided potential adversaries with increased access to sophisticated technologies and sensitive information. As a result, insurgents in Iraq used cellular phone technology to trigger roadside bombs, and Al-Qaida cells in Afghanistan can use the Internet to provide secure communications and access to satellite imagery. These are but two examples of negative impacts caused by the diffusion of low cost, advanced technology via globalization. If terrorist groups were to come into possession of more sophisticated military technology, the consequences could be dire. However, unlike cellular phones, advanced military technology is tightly controlled by the United States and its allies. It is true that globalization may increase the likelihood of cutting-edge technologies ending up in the hands of adversaries—either rogue terrorist groups or nation-states—because the technologies will be more widespread. One need only look to the example of the F-35, which will be used by a number of different countries. However, the solution in this regard is better control of technologies through multilateral agreements with allies. The choice is clear: The United States can forgo the use of cutting-edge defense technologies, paying more for inferior performance, while other nations (allies and adversaries alike) can benefit from collaboration, better weaponry, and as a result, achieve superior military forces.

### Loss of Technical Expertise

Similarly, the continued migration of manufacturing capabilities may produce increased national security risks in the future if they are not properly mitigated. Indeed, the loss of manufacturing capability is frequently followed by the loss of design and innovative capabilities for the affected

industry segment. One only need look at the personal computer (PC) to understand how the initial outsourcing of the assembly of printed circuit boards led to the pursuit of higher-value-added work, including the assembly of the complete product. Eventually, these firms assumed design-engineering tasks; today, virtually all Windows notebook PCs are designed and manufactured overseas. The same type of migration is apparent in other industries and products (consider, for example, the offshore Boeing composite work on the 787).

It seems that globalization may lead to some loss of expertise in production of defense industrial goods. Over time, this could pose a significant problem. For instance, protectionists say that the DoD and American industry might be unable to judge the quality of foreign-produced goods, or that in the event of a global calamity, the United States might find it very difficult to move production back to the domestic industrial base. Again, the solution to these problems is relatively straightforward: The United States must ensure that it retains the ability to design and produce critical technologies.

Yet critics assert that America can only retain said capabilities by eschewing globalization and focusing on domestic design and production. This assertion relies on the observation that the emergence of truly transformative innovation seems to occur most readily within an environment that facilitates the gradual refinement of products. But this is largely the American paradigm. While there is no doubt that it has led to great technical innovation, there are other models of success. In Japan, for example, transformative innovation is rare. Rather, Japan is well-known for improving technologies that were initially designed in other countries. As a result, the Japanese consistently rank higher than the United States in technical industries such as electronics, automotive, and materials development. Clearly, then, there is no reason to think that the United States must maintain all of its current design and production capabilities in a particular field in order to integrate, and even improve, new technologies.

In addition, more deliberative, global monitoring of new technologies, by both the DoD and industry, should allow the United States to keep pace with global innovation. The refusal to recognize that defense industry globalization is already underway is the greatest obstacle to enacting such a policy.

### Counterfeit Parts

Globalization has fueled the growth of counterfeiting in many industries. The defense industry is no exception. According to the U.S. Department of Commerce (2010), between 2005 and 2008, the number of counterfeit incidents reported by the DoD more than doubled: from 3,868 to 9,356. Counterfeit parts can affect the safety, operational readiness, costs, and critical nature of the military mission. The DoD procures millions of parts through its logistics support providers—DLA supply centers, military service depots, and defense contractors—who are responsible for ensuring the reliability of the DoD parts they procure. But as they draw from a network of suppliers in an increasingly global supply chain, the challenge of ensuring the integrity and provenance of parts and components has grown geometrically more complex. In addition, as DoD weapons systems age, products required to support it may no longer be available from the original manufacturers or through franchised or authorized suppliers. It is typically less expensive to find part substitutions and aftermarket manufacturing for needed electronic parts than reengineering and redesigning parts and components. As a result, the DoD is again at risk of purchasing counterfeit parts.

Protectionists state that significantly reducing, or even eliminating, reliance on foreign sources is the only way that the United States can completely ensure against the use of counterfeit parts. This may be true. But the DoD is not interested in reducing the risk to zero, but rather, in achieving a realistic balance between military superiority (which demands the purchase and use of foreign parts) and risks to national security. Once this balance is accepted as policy, the DoD can move forward to improve risk-mitigation strategies by, for example, adopting regionalized supply chains to reduce supplier and transport risk, and by strengthening and standardizing existing identification and disposition processes, standards, and contract requirements for counterfeit materiel across the global supply chain.

# V. Towards a Globalized Defense Industrial Base

Given the realities of post–Cold War defense policy, the formerly segregated defense industries of Western countries have begun to transform themselves into a global, more commercially oriented industry. They have done so through consolidations, mergers, acquisitions, joint ventures, and integrations that cross national boundaries. It should be noted that the globalization of the defense industry began at both ends, both by U.S. defense firms seeking foreign markets and by foreign defense firms seeking an entry into the largest of all markets for defense goods, the United States.

American aerospace and defense companies not only sell their goods and services abroad, but they are also setting up operations to research, test, produce, and manufacture in other countries as well. On the other side of this exist the foreign companies, principally European in origin, that have increasingly established themselves as part of the U.S. aerospace and defense industry. By purchasing U.S. companies or establishing U.S. subsidiaries, these foreign defense companies have gained a significant foothold in the largest defense market in the world, contributing in large part to the domestic U.S. economy.

Despite current policies, the United States has slowly begun to recognize the benefits of a globalized world. In fact, it is clear that the U.S. defense industrial base has undergone a sea change in its composition, becoming increasingly reliant on international sources for its development, production, and provision. Non-U.S. firms are major players within the U.S. defense industrial base—often with major engineering and production subsidiaries in the U.S. In fact, in 2012, 20 aerospace and defense firms made the Forbes Global 2000 List of the largest public companies operating in the global market. Eleven of these firms have their headquarters based outside of the United States (see Figure 8), including BAE Systems, EADS, and Thales. These firms regularly compete alongside Lockheed Martin, Northrop Grumman, and Boeing for contracts with the U.S. government. Moreover, these companies often work with each other across national boundaries. Below, we highlight instances in which the United States has relied on foreign components as well as foreign partnerships in order to procure superior systems. These ventures mark the defense industry's move toward globalizing its supply chain.

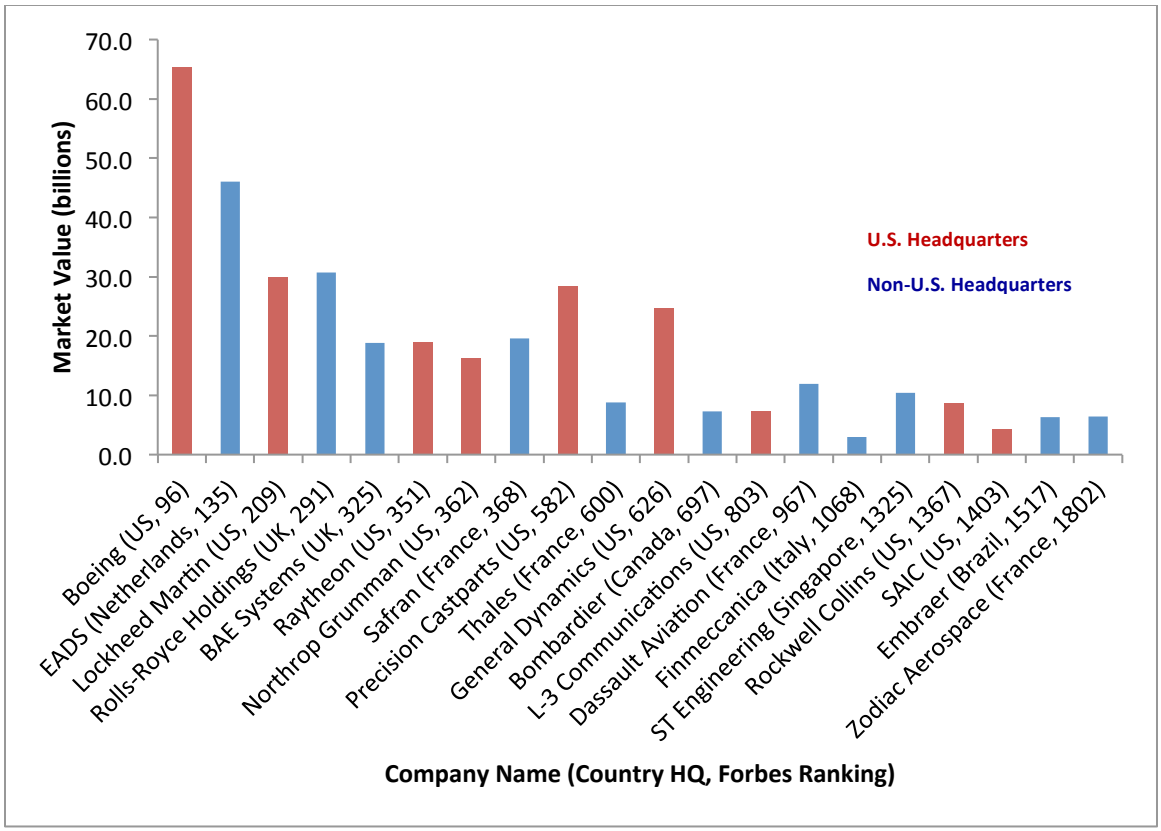


**Figure 8. Market Value of the Largest Global Public Aerospace and Defense Companies**
(*Note*. The information in this figure came from Forbes, 2013)

## *The MRAP*

The Mine-Resistant Ambush-Protected (MRAP) vehicle, one of the largest and fastest industrial mobilization efforts since World War II, was based on a vehicle hull design from South Africa and included state-of-the-art vehicle armor developed in Israel, special shock absorbers from Germany, and some Asian electronics. In May of 2007, Defense Secretary Gates declared the MRAP DoD's top acquisition priority (due to the growing number of deaths and casualties from roadside bombs in Iraq) and called for "any and all options to accelerate the production and fielding of this capability" (Osborn, 2007). Once the requirement was formally approved, the vehicles began to arrive in theater within six months (Gansler, Lucyshyn, & Varettoni, 2010). The success of this effort can be attributed, in large part, to the DoD's ability to rely on foreign designs, technologies, and suppliers—and, oftentimes the foreign-owned companies will set up a U.S. subsidiary for production (in this case, the Israeli armor is being produced in New England).

## *The Airborne Laser*

The Airborne Laser System (YAL-1A) serves as another example of international collaboration. American firm Lockheed Martin designed and built the LASER beam control/fire control system, which was mounted in a modified Boeing 747-400F aircraft. The German company, Heraeus Quarzglas, produced the 340-pound quartz window, mounted in the nose turret. The quartz glass produced by Heraeus Quarzglas is free from inclusions, preventing scattering of the laser beam, which maximizes the laser's capabilities and prevents the glass from cracking (Heraeus Quarzglas, 2013). New York-based Corning Inc. shaped the window into a dome. Finally, Pennsylvania-based L-3 Integrated Optical Systems Brashear, formerly known as Brashear LP and Contraves Brashear Systems, polished, optically coated, and installed the turret window into the nose of the aircraft (Heraeus Quarzglas, 2013). Harnessing the resources of specialty companies from across the globe maximizes the weapons systems' capabilities.

## *The F-35 Joint Strike Fighter*

No defense program illustrates the role that non-U.S. firms play in developing and manufacturing American weapons systems better than the previously discussed F-35 Joint Strike Fighter. Created to promote international cooperation and to produce an affordable warplane, the F-35 was planned to have 70 to 90 percent commonality for all the variants to reduce manufacturing, support, and training costs. The single-engine, single-seat F-35 was manufactured in three versions: a Conventional Takeoff and Landing (CTOL) variant for the U.S. Air Force, to replace the F-16 and A-10 and complement the F-22; an aircraft-carrier version (CV) for the U.S. Navy, to complement the F/A-18E/F; a Short Take Off Vertical Landing (STOVL) version for the U.S. Marine Corps, to replace the AV-8B and F/A-18A/C/D; and the STOVL variant (F-35B) for the U.K. Royal Air Force and Royal Navy to replace the Sea Harrier and GR7. The STOVL and CV variants underwent sea trials aboard American, British, and Italian aircraft carriers.

From Joint Direct Attack Munition (JDAM) equipped bombs to AIM-9 Sidewinders to the UK Storm Shadow, the F-35 has been designed to carry either internally or externally a large array of

weapons. The F-35's shape has no right angles, which reflect radar waves, and a special fiber coating makes it difficult to detect on any enemy radar (Rayment, 2013).

| Company | Part or Component | Part or Component Origin | Significance |
|---|---|---|---|
| **Lockheed Martin** | Final assembly | Texas | |
| | Forward fuselage | Texas | |
| | Wings | Texas | |
| **Lockheed Martin & Northrop Grumman** | Electric sensors—the Electro-Optical Distributed Aperture System (DAS) | Maryland | unique protective sphere around the aircraft for enhanced situational awareness, missile warning, aircraft warning, day/night pilot vision, and fire control capability |
| **Northrop Grumman** | Multi-Mission Active Electronically Scanned Array (AESA) radar | Maryland | effectively engage air and ground targets at long range, while also providing outstanding situational awareness for enhanced survivability |
| | Northrop Grumman Space Technology's integrated avionics | California | increased performance, quicker deployment, higher availability, enhanced scalability, and lower life-cycle costs |
| | Center fuselage | California | |
| **BAE Systems** | Aft fuselage | England | |
| | Horizontal and vertical tails | England | |
| **Pratt Whitney** | Engines | Connecticut | |
| **Rolls Royce** | Short Take Off Vertical Landing (STOVL) Lift System—patented by Lockheed Martin | Indiana; England | Lockheed Martin developed the idea for a Short Take Off Vertical Landing (STOVL) lift system that uses a vertically oriented Shaft Driven Lift Fan (SDLF). A two-stage low-pressure turbine on the engine provides the horsepower necessary to power the Rolls-Royce–designed Lift Fan. |

**Figure 9. Joint Strike Fighter Program: Companies and Components**
(*Note*. The information in this figure came from Randall, Nowicki, & Hawkins, 2011)

Following an intense four-year competition, the U.S. DoD named the American firm Lockheed Martin the prime contractor to develop the F-35 Lightning II in 2001 with two principal partners: American firm Northrop Grumman and British firm BAE Systems.

Subcontractors for the program include the British firm Rolls-Royce as well as other multinational firms (see Figure 10). The program's 10-year system development and demonstration (SDD) phase included the development, testing, and manufacture of the entire aircraft system with a resulting 22 test aircraft (F-35 Lightning II, 2012).

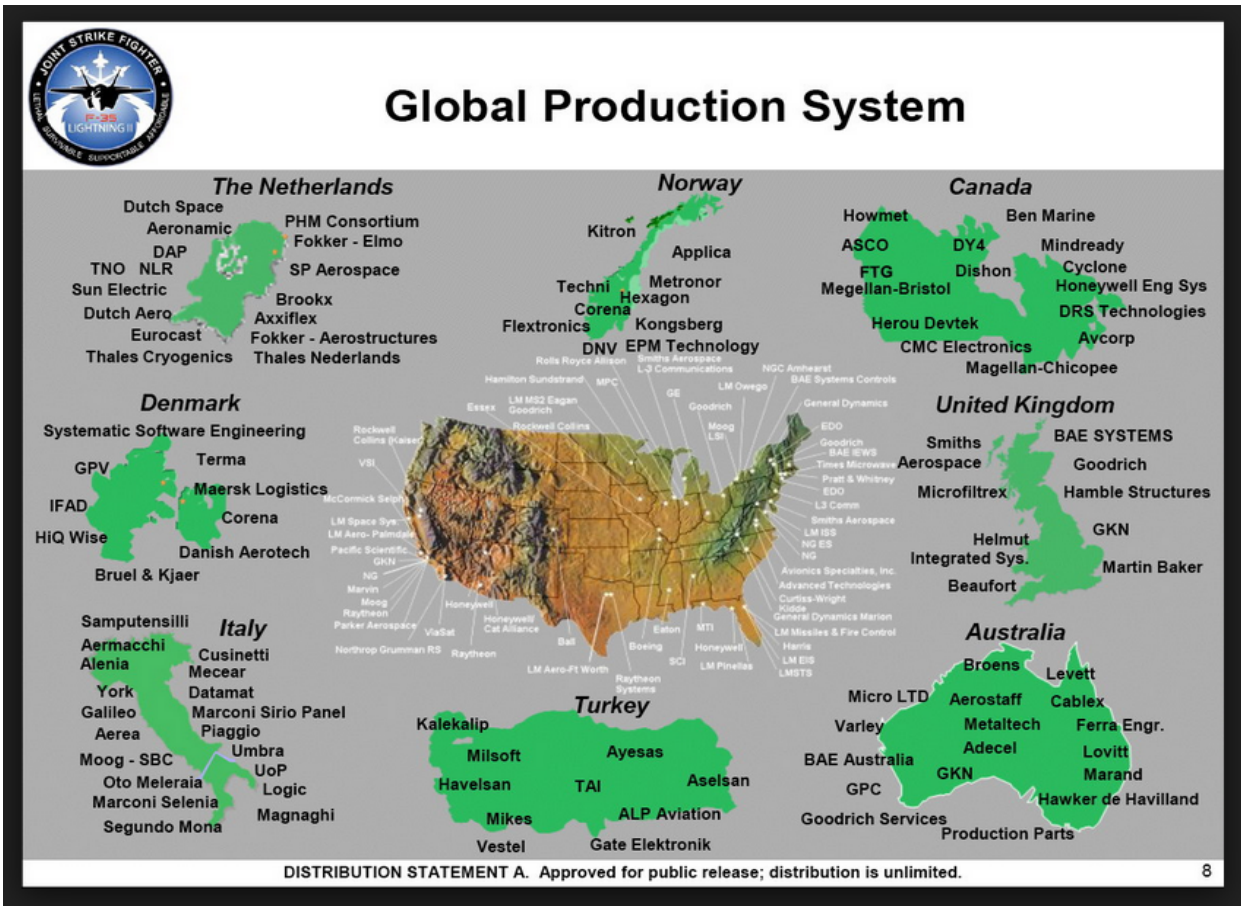


**Figure 10. JSF Participant Companies Across the Globe** (Defense Industry Daily, 2008)

Nine nations partnered in the F-35's 10-year SDD phase: the United States, United Kingdom, Italy, the Netherlands, Turkey, Canada, Denmark, Norway, and Australia (see Figure 10). These nations contributed about $4.5 billion total in cash and in kind, or about 14 percent of total program costs (see Figure 11). Additionally, Israel and Singapore agreed to join the program as

Security Cooperation Participants, contributing $50 million each. By partnering with the United States during SDD, firms in these countries could bid for work on a "best value" basis, and participate in the development and acquisition of the aircraft. (The stated DoD objective was to acquire the "best in class" for each element of the system.)

| Country | Contribution (in millions) | Percentage of total costs |
|---|---|---|
| UK | $2,056 | 6.2% |
| Italy | $1,028 | 3.1% |
| Netherlands | $800 | 2.4% |
| Turkey | $175 | 0.5% |
| Australia | $144 | 0.4% |
| Norway | $122 | 0.4% |
| Denmark | $110 | 0.3% |
| Canada | $100 | 0.3% |
| **Total partner** | $4,535 | 13.7% |
| | | |
| US | $28,565 | 86.3% |
| | | |
| Israel | $50 | |
| Singapore | $50 | |

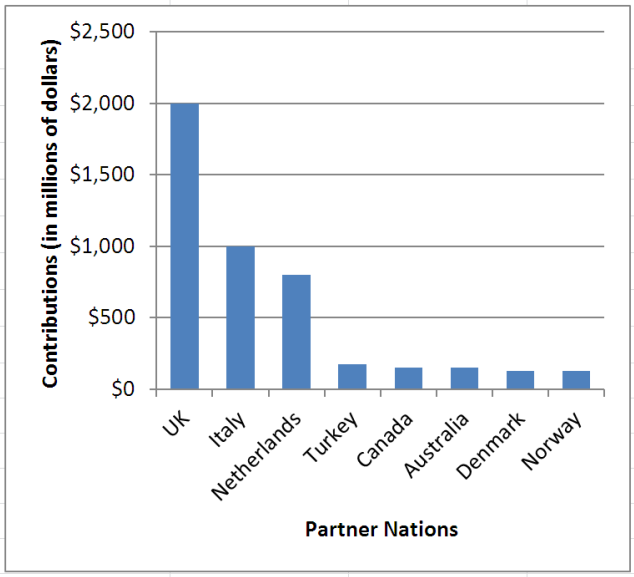


**Figure 11. Contributions to the JSF Program**
(*Note*. The information in this figure came from GAO, 2003)

International collaboration resulting from the JSF program has provided risks and opportunities. Opportunities included strengthening coalitions and reducing research and development costs for all parties. The inclusion of nations from NATO, the North American Aerospace Defense Command (NORAD), and The Australia, New Zealand, United States Security Treaty (ANZUS) in a high-technology weapons program has fostered trust between these nations in sharing technology and resources. In the future, the interoperability and shared resources and technology can provide improved capabilities and allied responses. Production of components in each collaborating nation provided jobs in all the countries and ensured the continued existence of defense firms which otherwise may have been forced to close, due to lack of work. For example, the JSF program provides the UK with over 25,000 jobs at 130 UK companies (note that there are only 517,000 A&D jobs in all of Europe; AeroSpace & Defence Industries Association of Europe, 2012; Eshel, 2012). Norway's Kongsberg Defence Systems President Harald Ånnestad estimated that the JSF program is worth 450 jobs and $4.2 billion for Kongsberg alone

("Kongsberg's," 2013). Before a 2003 House subcommittee, Deputy Under Secretary of Defense Suzanne D. Patrick cited examples of companies that have benefited from the JSF program:

> Evidence already abounds that the program is reshaping the global defense industrial base. … The program will dramatically increase the scale of many small and mid-size companies in the global defense industrial base. A Canadian specialty semiconductor chip manufacturer grew from 12 to 15 employees because of its position on the JSF program. Another 40-employee company, which develops decision support software, is forecast to source average annual JSF revenues in System Development and Demonstration/Low Rate Initial Production (SDD/LRIP) in line with its average total corporate revenues in the 2001–2002 timeframe. In Full Rate Production (FRP), this company's revenues from JSF could average over ten times 2002 revenue. At these growth rates, some of the smallest JSF suppliers could find themselves shoulder-to-shoulder with the blue chip giants of the industry as a result of being part of this program!

As with any large, complex project, there are risks that must be managed. The lack of perceived transparency and fairness of competitive bidding as well as decreased supplier visibility have potentially increased risk. As early as 2003, companies such as Norway's Kongsberg complained that non-U.S. companies faced an uneven playing field and barriers to compete for JSF contracts related to U.S. company preferences and technology-transfer complications. As free and open international competition becomes the norm in the future, complaints of this nature should dissipate.

Additionally, the F-35 sources materials and subcomponents from 1,300 suppliers, including sole-sourcing the aircraft's ejection seat to a foreign supplier, making the U.S. military reliant, for the foreseeable future, on foreign sources (Adams, 2013). However, some components are produced by multiple firms. In Italy, for example, which began assembly of its F-35s in July 2013, wings for its first order will be produced by Lockheed Martin, but subsequent aircraft orders will rely on wings produced by Alenia Aermacchi, an Italian company (Kington, 2013).

Despite recent decisions by partner countries to reduce their planned inventories, their initial financial contributions and revised commitments nevertheless significantly defray the cost of the aircraft to the United States. Had the United States pursued the F-35 alone, the program very well could have been canceled in the late phases of production, despite heavy initial investment,

leaving the United States military without an advanced air superiority fighter, one that is expected to remain in the DoD's arsenal for some 30 years.

# VI. Embracing Change

The United States must come to realize that defense industry globalization is already underway and in order to maximize the associated benefits, the nation must embrace this change and focus on some of the associated challenges. Denying the reality of defense industry globalization, or insisting that the United States could just as easily pursue a protectionist policy is counterproductive. Below we highlight two such challenges: achieving interoperability, both strategic and technical; and maintaining competency in science and technology fields.

## *Achieving Interoperability*

The frequency and scope of coalition operations continue to increase. Given current trends toward military cooperation and America's increasing reluctance (for geopolitical reasons) to unilaterally engage in conflict, the formation of multinational battle groups seems all but inevitable. Yet technical interoperability among U.S. and allied forces continues to pose a major obstacle. Austin (2008) writes that the "levels of technical and non-technical interoperability are significantly below the level where seamless interaction between tactical units of differing national contingents can take place" (p. 2).

One need only look to the invasion of Kosovo, and more recently to the wars in Iraq and Afghanistan, where coalition operations were severely hindered by disparities in communication and equipment. Even among the major branches of the U.S. armed forces, there are interoperability issues. Currently, the U.S. military relies on 25 families of radios that, for the most part, are incompatible and render inter-service communication (as well as mixed voice and data communication) difficult and costly.

It is tempting to believe that as a natural consequence of defense industry globalization, U.S. and allied military systems will co-evolve into highly interoperable systems, providing coalition forces with a major strategic advantage when conflicts arise. But this is not necessarily the case. Defense industry globalization could take the form of head-on competition between the leading European-based defense firms (named in the previous section) and U.S.-based firms, resulting in

the bifurcation of the defense technology base, not to mention the transatlantic alliance itself. The split would likely render U.S. and European systems non-interoperable.

Globalization must be harnessed appropriately in order to achieve the desired outcomes. Firms based in both Europe and the United States must be encouraged to fully compete for contracts awarded by governments on both sides of the Atlantic in order to facilitate interoperability and take advantage of the benefits that derive from competition. For political reasons (often disguised as economic ones), some in Congress suggest that U.S. firms should be given preference in the procurement process. These suggestions are misguided. And one need not merely cite macroeconomic arguments (i.e., competitive advantage, or the necessity of "creative destruction" that results in localized job loss) to make this point. The fact is that many European foreign defense firms (and all 11 of the European firms depicted in Figure 9 in the previous section) have significant U.S.-based operations. Their U.S.-based production and their employment of U.S. citizens may even exceed that of U.S. firms that offshore their production.

But even open competition among countries cannot guarantee interoperability. Austin (2008) suggests that the perceived nexus between a globalized defense industry and interoperability may not even exist. Collaboration does not always translate to interoperability. The reasons for this are many. First and foremost, national security regulations tend to restrict the transfer of cutting-edge technology (via "export controls"), which, in turn, limits technical interoperability among nations. Another problem resides in the fact that the United States spends significantly more on defense. As a result, the technical gap between the United States and European countries continues to widen, rendering technical interoperability among systems difficult to achieve.

### *Maintaining Competency in S&T*

It has long been suggested that globalization helps poorer nations "catch up" to industrialized ones quickly, through increased employment and technological advances. It has also been observed that globalization allows less industrialized countries to bypass outdated technology and infrastructure—for example, a poor country need not build an expansive landline telephone network to take advantage of cellular communication. In fact, a country that starts development with a blank slate is better positioned to maximize the efficient use of cutting-edge technologies,

in that it does not have to incorporate them into existing networks and infrastructures. Although this aspect of globalization is clearly beneficial, there is reason to believe that this same process potentially enables today's less-developed nations to match—and in some cases overtake—developed countries, including the United States, in some fields of science and technology (S&T).

For some time, the United States has been dominant in most fields of S&T. In the latter half of the last century, almost half of all scientists and engineers conducting research were doing so in the United States. This has changed rapidly in the intervening years. Globalization has facilitated the easy transfer of advanced technologies and the know-how to use them successfully. The fast GDP growth of developing nations, combined with U.S. demographic reality (every day in America, 10,000 people age into social security), and the fact that many U.S. students have been choosing not to go into S&T, all but guarantee that American dominance in S&T will continue to decline. In fact, recent estimates by Coffey & Ramberg (2012) suggest that the U.S. share of S&T productivity will continue to decrease from 26 percent in 2005 to 18 percent in 2050. In order to remain economically and militarily competitive, the U.S. must remain cognizant of changes and trends in global S&T. This is one of the major challenges of the future.

This is, of course, a challenge that the United States must face. There is no alternative. Failure to embrace the globalization of S&T in general, or defense industry globalization in particular, will isolate the United States from the newest developments, the majority of which will soon occur in other countries. In order for the DoD to shape and take advantage of the technologies of tomorrow, it should embrace industry globalization by relying on the best technologies available, allowing foreign access to certain American technologies, and building partnerships within the global S&T community.

## *Conclusion*

Foreign firms such as BAE Systems, Finmeccanica, EADS, Thales, Plasan, Serco, and so forth, all have U.S.-based subsidiaries, with special security boards designed to mitigate risks, real and perceived, that are associated with foreign contracting. It is clear that business has already decided that the defense market should be globalized. However, U.S. defense policy (such as

import and export control) does not always embrace this new reality. Clearly, defense industrial base globalization is already well underway. Denying this reality, or insisting that the United States could just as easily pursue a protectionist policy, is counterproductive, especially in light of emerging challenges.

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In 2007, Dr. Gansler served as the chair of the Secretary of the Army's Commission on Contracting and Program Management for Army Expeditionary Forces. He is a member of the Defense Science Board and the Government Accountability Office (GAO) Advisory Board. He is also a member of the National Academy of Engineering and a fellow of the National Academy of Public Administration. Additionally, he is the Glenn L. Martin Institute Fellow of Engineering at the A. James Clarke School of Engineering; an affiliate faculty member at the Robert H. Smith School of Business; and a senior fellow at the James MacGregor Burns Academy of Leadership (all at the University of Maryland). From 2003–2004, Dr. Gansler served as interim dean of the School of Public Policy at the University of Maryland, and from 2004–2006, he served as the vice president for research at the University of Maryland.

**William Lucyshyn**

William Lucyshyn is Director of Research and Senior Research Scholar at the Center for Public Policy and Private Enterprise in the School of Public Policy at the University of Maryland. In this position, he directs research on critical policy issues related to the increasingly complex problems associated with improving public-sector management and operations and with how government works with private enterprise.

His current projects include modernizing government supply-chain management, identifying government sourcing and acquisition best practices, and analyzing Department of Defense business modernization and transformation. Previously, Mr. Lucyshyn served as a program manager and the principal technical advisor to the Director of the Defense Advanced Research Projects Agency (DARPA) on the identification, selection, research, development, and prototype production of advanced technology projects.

Prior to joining DARPA, Mr. Lucyshyn completed a 25-year career in the U.S. Air Force. Mr. Lucyshyn received his bachelor's degree in engineering science from the City University of New York and earned his master's degree in nuclear engineering from the Air Force Institute of Technology. He has authored numerous reports, book chapters, and journal articles.

**John Rigilano**

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The Center for Public Policy and Private Enterprise provides the strategic linkage between the public and private sector to develop and improve solutions to increasingly complex problems associated with the delivery of public services — a responsibility increasingly shared by both sectors. Operating at the nexus of public and private interests, the Center researches, develops, and promotes best practices; develops policy recommendations; and strives to influence senior decision-makers toward improved government and industry results. The Center for Public Policy and Private Enterprise is a research Center within the University of Maryland's School of Public Policy.